Assessing the Reliability of Self-Reports

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Background

- Vessels report themselves through various means:

  - Automatic Identification System (AIS)

  - Vessel Monitoring System (VMS)

  - Long Range Identification & Tracking (LRIT)

  - Weather reports

  - Pre-arrival notifications to authorities

  - etc.

- Self-reporting increasingly becoming mandatory (e.g., AIS now required for all ships $\geq$ 300 GT engaged on international voyages).

- A significant fraction of the data entering the recognized maritime picture is now coming from self-reports.

Issues

- Self-reporting systems are not tamper-proof. Vessels may report incorrect information, deliberately or not.

- Self-reports should be verified, to some extent, using other information sources.

- Various means of verification: aerial patrols, surface patrols, imagery, etc.

- Verifying all self-reports is impractical and not cost-effective.

- Key questions from the operators:

  – How many vessels should be verified?

  – Which ones?

How Many?

How many self-reporting vessels should be verified in order to reach a certain confidence level that the information received from <u>all</u> unverified vessels is correct?

- To answer this, some prior estimate of the fraction f of the vessel population that transmits incorrect information is required.

- Analysis performed on AIS reports (Gauthier, 2006). Estimated f for three types of "errors":

  - insignificant (e.g., non-mandatory field missing);

  - minor (e.g., typo in ship name); and

  - serious (e.g., wrong ship location).

How Many?

- Let

  $(1 - f)$ = probability that each vessel reports correct information;

  N_R = number of self-reporting vessels; and

  N_V = number of self-reporting vessels verified.

- Assume independence between vessels and perfect error recognition.

- Also assume uniform sampling *without replacement* (each vessel is randomly selected and verified only once during a patrol).

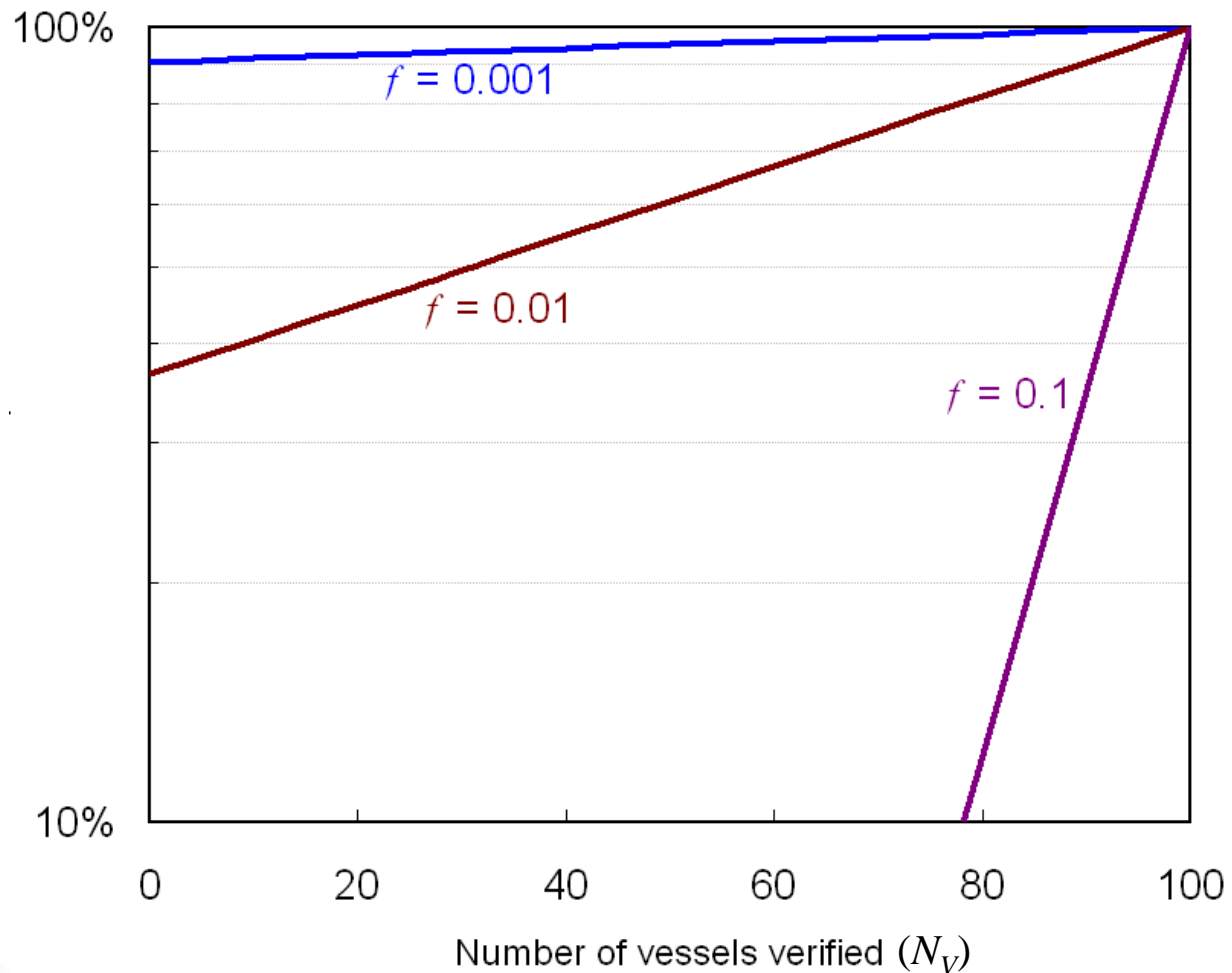- Probability P that all unverified vessels report correct information = $(1 - f)^{(N_R - N_V)}$

$$N_V = [log(P) - N_R \, log(1 - f)] \, / \, (1 - f)$$

How Many?

Example: Probability that *all* unverified vessels report correct information (with $N_R = 100$ vessels reporting)

How Many?

- Example of a simple spreadsheet-based estimation tool for operators.
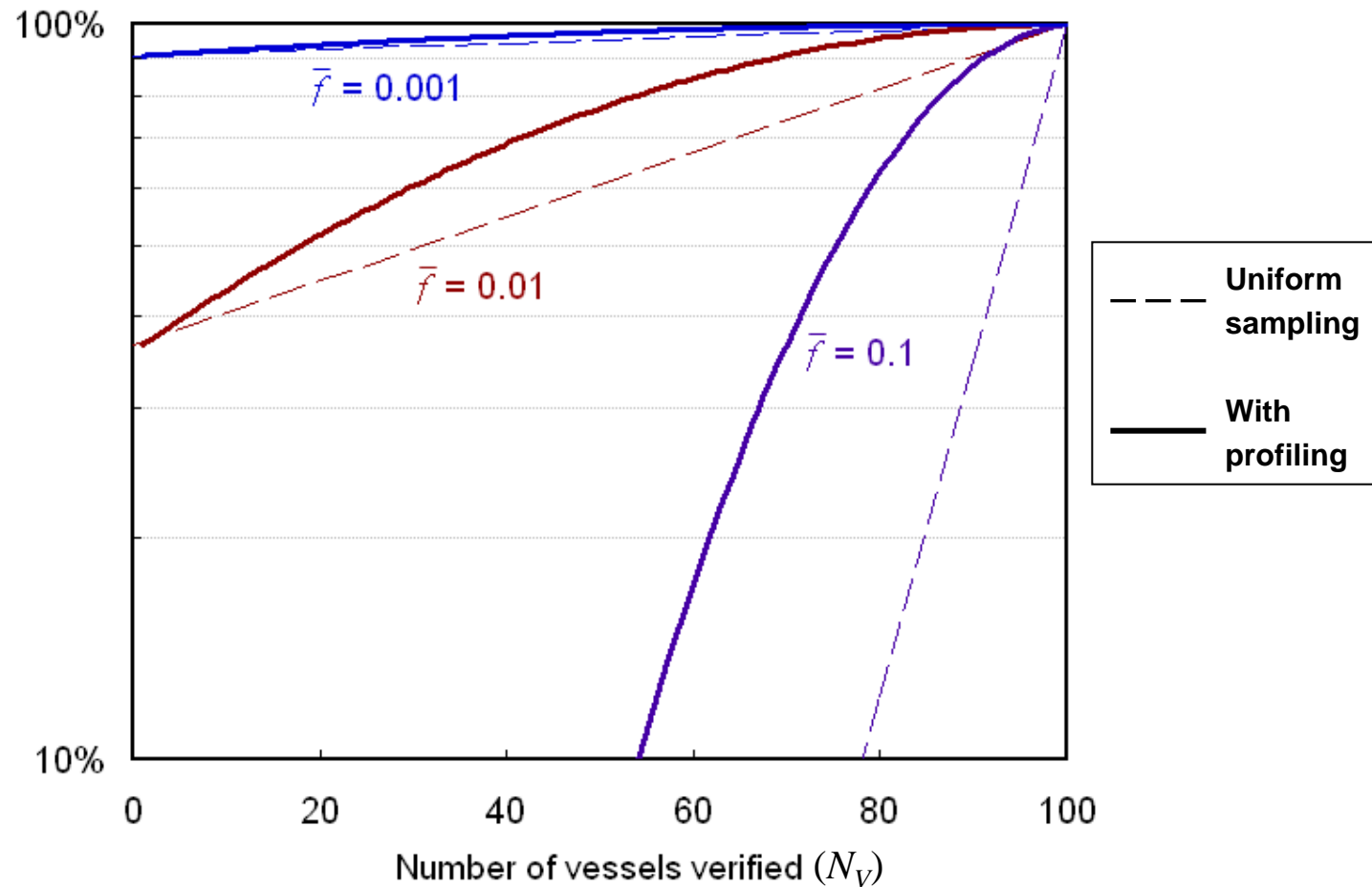
Which Ones?

- Uniform sampling is not the most efficient selection method.

- What if a meaningful probability f_i of reporting incorrect information can be assigned to each vessel $i = 1, \ldots, N_R$?

- Optimal verification strategy:

  - Sort f_i's from largest to smallest value.

  - Focus available time and resources on vessels with the highest f_i's.

Which Ones?

Example: Probability that *all* unverified vessels report correct information (with $N_R = 100$ vessels and $f_i = i \cdot \overline{f} / 2$)

$\overline{f} = 0.001$

$\overline{f} = 0.01$

$\overline{f} = 0.1$

– – – Uniform sampling

——— With profiling

Number of vessels verified (N_V)

Which Ones?
Case with replacement

- Consider now a very large area monitored over a very long period (e.g. 1 year)

- A vessel may then be verified multiple times by multiple patrols, patrol assets, or agencies. This is sampling *with replacement*.

- Does the optimal verification strategy remains the same?

Which Ones?
Case with replacement

- No!

- "Strong profiling is not mathematically optimal for discovering rare malfeasors" (W.H. Press, *Proceedings of the National Academy of Sciences*, Feb 2009)

- When sampling proportionally to the f_i's (strong profiling), resources are wasted on the repeated verification of vessels that are correctly reporting.

- Priors should be used, *but only weakly*.

Which Ones?
Case with replacement

- Optimal verification strategy:

  – Estimate f_i for every vessel.

  – Perform *square-root biased* sampling (proportional to $\sqrt{f_i}$) on the vessel population.

- Example:

  – If a vessel is *a priori* 25 times more likely than average to report incorrect information, it should be verified only 5 times more frequently than average.

- Theoretically valid for any type of vessel profiling, although not all profiling methods may be legal or feasible.

Operational Considerations

- Self-report verification is generally not the primary objective of surveillance activities.

- Even if verification is performed as a secondary task, operators should:

  - record number of verifications and details of incorrect reports;

  - record reporting vessel characteristics; and

  - refine priors as more data becomes available.

- In practice, sampling involves tradeoffs between verification effort (time, distance) and the number of vessels verified.

- If priors can be assigned to different categories of vessels, sampling should be kept roughly proportional to $\sqrt{f_i}$.

Conclusion

- Simple statistical methods can be easily implemented by authorities to assess the reliability of self-reports.

- More sophisticated Bayesian procedures could also be investigated (e.g., procedures based on anomaly detection).

- Good estimates of the priors are key to reliability assessments. Verification results should be compiled and analyzed on a regular basis to refine priors.

- Enforcing regulations more stringently would increase self-report reliability in the medium term. Verification data could be used to measure the impact and cost-effectiveness of this enforcement.

Comments?
Questions?

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